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POLARIZATION MEASUREMENTS OF ZODIACAL LIGHT

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SUMMARY

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The results of polarization measurements of zodiacal light, conducted in 1955, are expounded. Determinations were made of the absolute brightness of zodiacal light in blue and green rays in polarized as well as in natural light. The course of brightness distribution of zodiacal light along the ecliptic and perpendicularly to it was approximated by an analytical expression. It was found that the color of the zodiacal light is near that of the Sun. The degree of polarization at various points of the zodiacal light cone in the regions $15^\circ \leqslant \beta \leqslant 25^\circ$ and $30^\circ \leqslant \varepsilon \leqslant 65^\circ$. has been determined.

* * *

Measurements of the intensity and of the degree of polarization of the zodiacal light were conducted at the "Kamenskoye Plato Observatory" ($\lambda = 43.2^\circ$ N, $\varphi = 76.9^\circ$ E, H = 1450 m. above the sea level) in September-October 1955. Polarization measurements were conducted by the three polaroid position method [1] with the help of an electrophotometer [2]. Two glass filters were utilized, a blue one (SZS-12 glass) and a green one (ZHS-glass) with effective pass-band wavelengths respectively equal to 470 and 520 millimicrons. The effective wavelengths were computed for the solar spectrum by the formula

$$\lambda_{\text{эфф}} = \frac{\int \lambda S(\lambda) F(\lambda) P(\lambda) G(\lambda)\, d\lambda}{\int S(\lambda) F(\lambda) P(\lambda) G(\lambda)\, d\lambda},$$

*Polyarizatsionnyye izmereniya zodiakal'nogo sveta.

where $S(\lambda), F(\lambda), P(\lambda), G(\lambda)$ are respectively the energy distribution in the solar spectrum, the relative spectral sensitivity of the photomultiplier FEU-19, the filter and glass transmission.

The curves of filter transmission taking into account the sensitivity of the photomultiplier and the transmission of the glass optics, are represented in Fig. 1. The observations were conducted along the almucantars $z = 40, 50, 60, 70, 80^\circ$ at every 10° by azimuth. The ecliptic and galactic coordinates of the observed points of the sky were computed graphically, thus ensuring a precision to 1°. The observed sky brightnesses were expressed in stellar units of the 10 mg class G_2 from sq.deg. by way of tying to stars of well known brightness and spectral class. The brightness of zodiacal light I_z was determined by the formula [3]

$$I_z = [\, I_0 - A(z) - L(b)\, p^{\sec z} - R(b,z,p)\,]\,(p + 0.02)^{-\sec z}.$$

Here I_0 is the observed sky brightness; $A(z)$ is the atmosphere compenent of the night sky glow, assumed to be independent from the azimuth (we took for $A(z)$ the atmosphere component, measured on the given almucantar, but remote from the cone of zodiacal light); $L(b)$ is the stellar component, determined according to Tables, compiled from the results of the work [4] in the assumption, that the stellar component in the galactic pole is equal to 28 stras 10 mg from a sq.degree. The brightness $R(b, z, p)$, conditioned by scattering of star light in the troposphere, was determined according to data from [3]. It must be noted that the correction for the direct and scattered star light were not great, inasmuch as only those points were utilized, whose galactic latitude does not exceed 20°.

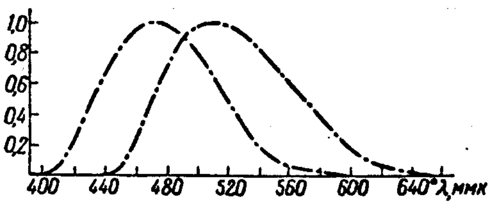

Fig. 1

The transparency factor of the terrestrial atmosphere p, was measured for each observed point of the sky. The intensity of the polarized radiation I_p may be found from the formula $I_p = PI$, where I is the intensity of the zodiacal light in the total light (polarized + non-polarized radiation).

According to the values of I and I_p found for each point of the sky, these intensity were derived by graphic interpolation for some chosen points at each 5^o along the ecliptical longitude and latitude. Such method permitted to obtain the values of I_p and I for every day at the very same points of the celestial sphere and to average the values for all the days of observations.

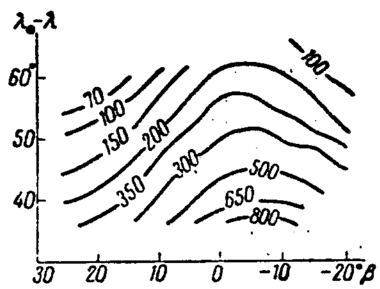

Fig. 2

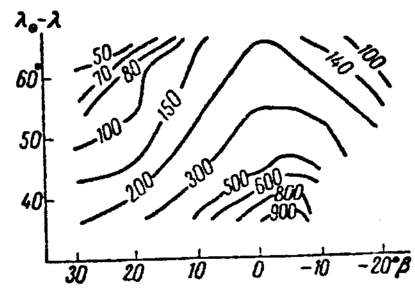

Fig. 3

We compiled in Table 1 the averaged brightnesses of the zodiacal light along the ecliptic, expressed in the number of stars of the 10 mg class G_2. and in Figs. 2 — 5, we plotted the isophots of the zodiacal light in the integral and in polarized light of two filters utilized (Figs. 2 and 3 in integral light for the blue and green filters, Figs. 4 and 5 in polarized light, respectively for the blue and green filters).

TABLE 1

$\lambda_\odot - \lambda^\circ$		35	40	45	50	55	60	65
Integral Light	blue green	800 905	600 670	430 460	335 350	260 280	200 220	— 200
Polarized Light	blue green	130 150	100 140	85 110	69 83	58 63	46 59	— 43

It may be seen that in the integral light (Figs 2, 3) the isophots widen in the northern part of the sky, to which attention was drawn more then once [5, 6]. However, this widening is absent in polarized radiation. As may be seen from Figs 4 and 5, in polarized light the isophots run in the northern part of the sky at a small angle to the ecliptic. It is clearly seen, that along a circle, for example $\lambda_\odot - \lambda = 40°$, the isophot inclination to the ecliptic decreases with the distance from it.

In the integral light (Figs. 2, 3) the picture is opposite. Here the inclination of the isophots increases with the distance from the ecliptic, which in fact represents indeed the isophot widening. Therefore, the result obtained shows that the widening of isophots in the northern part of the sky is conditioned by nonpolarized radiation or, at the very least, by radiation with a very low degree of polarization.

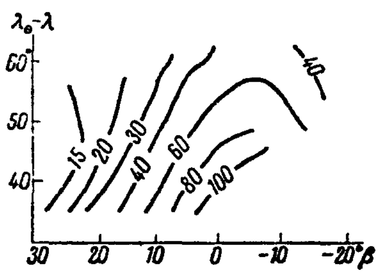

Fig. 4

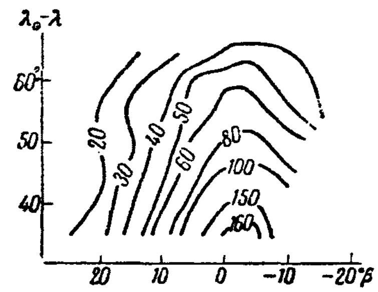

Fig. 5

The isophots were found to be nonsymmetric in the integral, as well as in polarized light, relative to the ecliptic. The maximum brightnesses of zodiacal light at small elongations were noticeably displaced to the south of the ecliptic. As the elongation increases, the summits of the isophots approach the ecliptic, so that the axis of the zodiacal light results to be inclined to the ecliptic.

The absolute brightnesses of the zodiacal light along the ecliptic (Table 1) are found to be somewhat lower than the values obtained in [7, 8], but rather near the values brought out in [9, 10].

The course of brightness along the ecliptic is usually represented by the dependence $I \sim \varepsilon^{-k}$. The values of k, determined by the method of the least squares, resulted for the elongation interval $35° \leqslant \varepsilon \leqslant 65°$ as follows: integral light, blue filter — $k = 2.7$, green filter — $k = 2.5$, polarized light, blue filter — $k = 2.2$, green filter — $k = 2.1$. As in [7], the values of k were found to be somewhat greater for the blue than for the green rays. The course of brightness perpendicularly to the ecliptic is sufficiently well approximated by the exponential function $I = I_0 \exp[-k_1(\beta - \beta_0)^2]$. , as is shown in [7]. Presented below are the values of k_1 for elongation interval 35 — 65°.

integral light, blue filter	$k_1 = 0{,}0027$	}	0,00275
" " green filter	$k_1 = 0{,}0028$		
polarized light, blue filter	$k_1 = 0{,}0032$	}	0,00335
" " green filter	$k_1 = 0{,}0035$		

TABLE 2

$\lambda_{\odot}-\lambda^{\circ}$		35	40	45	50	55	60
$\beta = 0^{\circ}$	integral light	0,15	0,16	0,13	0,10	0,04	0,09
	polarized "	0,14	0,08	0,13	0,15	0,15	0,02
average for the band $-10^{\circ} \leqslant \beta \leqslant 10^{\circ}$	integral light	0,23	0,14	0,08	0,15	0,14	—
	polarized "	0,14	0,11	0,11	0,14	0,15	—

Presented in the above Table 2 are the values of the quantity $2.5 \log(I_{green}/I_{blue})$ for the zodiacal light in the ecliptic and in the band $-10^{\circ} \leqslant \beta \leqslant 10^{\circ}$ along it, characterizing the color of the zodiacal light relative to that of the Sun.

The data obtained do not reveal any dependence of the color of zodiacal light on the elongation of the Sun, which agrees well with the results of the works [7, 9, 11]. As pointed out in [7, 9], the determination of the color of zodiacal light pertains to the most difficult part of photometric investigations of zodiacal light, and mainly because of the difficulties in accoutning strictly for the spectral transparency of the terrestrial atmosphere. That is why the most reliable results are obtained at averaging the observations of numerous nights. If we actually take the average of all observation nights by all points of the zodiacal light cone in the bands $-10^{\circ} \leqslant \beta \leqslant 10^{\circ}$ and $35^{\circ} \leqslant \beta \leqslant 60^{\circ}$, we obtain the following values of the quantity $2.5 \log(I_{green}/I_{blue})$: for the integral light — 0.14 ± 0.03, for the polarized light — 0.09 ± 0.04. (For the Sun these values are zero).

The last results, as well as the data of Table 2, show that the color of the zodiacal light in polarized and integral light is practically identical. This may serve as an indication that the same particles are responsible for both, the polarization of zodiacal light and the non-polarized radiation. The values of the root-mean-square errors obtained at the determination of the quantity 2.5 (I_{green}/ I_{blue}), characterize only the analogy of the result. The error, determined by an inaccurate accounting of the influence of terrestrial atmosphere transparency, is apparently significantly greater than that root-mean-square error. In connection with that, the result obtained must be viewed only in the sense, that the color of zodiacal light is near that of the Sun, which is in agreement with the results of other authors [7].

TABLE 3

β_0 \ $\varepsilon°$	30	35	40	45	50	55	60	65
—15	—	—	—	—	—	0,22	0,25	0,32
—10	—	0,16	0,20	0,25	0,24	0,28	0,27	0,30
— 5	—	0,18	0,18	0,20	0,21	0,23	0,26	0,32
0	0,14	0,17	0,17	0,20	0,21	0,22	0,24	—
5	0,12	0,14	0,16	0,19	0,21	0,23	0,25	—
10	0,12	0,14	0,18	0,18	0,20	0,22	0,23	—
15	0,12	0,13	0,14	0,17	0,18	0,21	—	—
20	0,13	0,14	0,10	0,13	0,15	0,21	—	—
25	0,14	0,12	0,10	0,11	0,19	0,19	—	—
—15	—	—	—	—	0,27	0,25	0,31	0,29
—10	—	0,17	0,17	0,22	0,22	0,23	0,22	0,27
— 5	—	0,17	0,18	0,21	0,23	0,22	0,27	0,30
0	0,16	0,17	0,21	0,22	0,23	0,22	0,23	0,23
5	0,13	0,15	0,21	0,21	0,22	0,23	0,29	0,21
10	0,08	0,12	0,17	0,17	0,22	0,23	0,24	0,29
15	0,08	0,11	0,14	0,16	0,16	0,22	0,22	0,25
20	0,07	0,08	0,11	0,11	0,12	0,17	0,16	0,17
25	0,08	0,10	0,09	0,10	0,21	0,17	—	—

Presented in Table 3 are the averaged values of the degree of polarization of the zodiacal light respectively in blue and green rays. As may be seen, there is no systematic difference between the degree of polarization in blue and green rays. The degree of polarization along the ecliptic increases from elongation of 30 to 60°, which is in contradiction with the result of the works [10, 12], but agrees well with the results of the works [9, 13 — 15]. The obtained values of the degree of polarization at the elongation of 60° are close to the data of [9, 11, 14], but lower than the values brought out in [13, 15]. The discrepancy in the values of the degree of polarization and of its course in the ecliptic, resulting from works of various authors, make difficult the choice of the model of dust cloud conditioning the zodiacal light phenomenon.

**** THE END ****

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